Electrochemical Glucose Biosensor of Platinum Nanospheres Connected by Carbon Nanotubes

Jonathan C. Claussen, M.S., Sungwon S. Kim, Ph.D., Aeraj ul Haque, M.S., Mayra S. Artiles, B.S., D. Marshall Porterfield, Ph.D., and Timothy S. Fisher, Ph.D.

Abstract

Background:
Glucose biosensors comprised of nanomaterials such as carbon nanotubes (CNTs) and metallic nanoparticles offer enhanced electrochemical performance that produces highly sensitive glucose sensing. This article presents a facile biosensor fabrication and biofunctionalization procedure that utilizes CNTs electrochemically decorated with platinum (Pt) nanospheres to sense glucose amperometrically with high sensitivity.

Method:
Carbon nanotubes are grown in situ by microwave plasma chemical vapor deposition (MPCVD) and electrochemically decorated with Pt nanospheres to form a CNT/Pt nanosphere composite biosensor. Carbon nanotube electrodes are immobilized with fluorescently labeled bovine serum albumin (BSA) and analyzed with fluorescence microscopy to demonstrate their biocompatibility. The enzyme glucose oxidase (GOx) is immobilized onto the CNT/Pt nanosphere biosensor by a simple drop-coat method for amperometric glucose sensing.

Results:
Fluorescence microscopy demonstrates the biofunctionalization capability of the sensor by portraying adsorption of fluorescently labeled BSA unto MPCVD-grown CNT electrodes. The subsequent GOx–CNT/Pt nanosphere biosensor demonstrates a high sensitivity toward H2O2 (7.4 µA/mM/cm2) and glucose (70 µA/mM/cm2), with a glucose detection limit and response time of 380 nM (signal-to-noise ratio = 3) and 8 s (t90%), respectively. The apparent Michaelis–Menten constant (0.64 mM) of the biosensor also reflects the improved sensitivity of the immobilized GOx/nanomaterial complexes.

Conclusions:
The GOx–CNT/Pt nanosphere biosensor outperforms similar CNT, metallic nanoparticle, and more conventional carbon-based biosensors in terms of glucose sensitivity and detection limit. The biosensor fabrication and biofunctionalization scheme can easily be scaled and adapted for microsensors for physiological research applications that require highly sensitive glucose sensing.